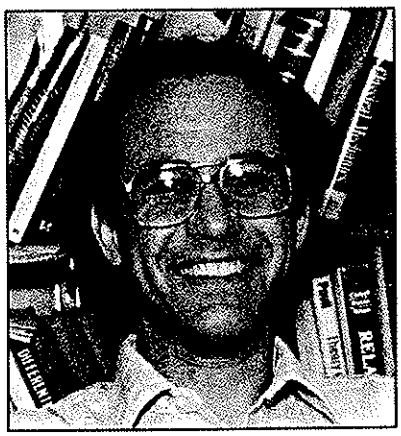
The acoustic pressures at the two ears fluctuate with frequency, at the two different rates $|\tau_l \pm \tau_h|/2$, but now in contrast to the total nulls which occurred in the case of time differences only, the ear pressures fluctuate between $(L + R)$ and $|L - R|$:

$$|L - R| \leq |P_L|, |P_R| \leq L + R \tag{18}$$

and so the interaural level ratio fluctuates within the band

$$\frac{|L - R|}{L + R} \leq \left|\frac{P_L}{P_R}\right| \leq \frac{L + R}{|L - R|} \tag{19}$$

as a function of the frequency ω. Geometrically, referring to Fig. 3, the phasors P_L and P_R rotate around ellipses specified by Eqs. (17) with semimajor axis $(L + R)$ and semiminor axis $|L - R|$, but at different rates. The ratio of their lengths $|P_L/P_R|$ fluctuates around unity in a complicated way as a function of frequency. (Remember that these conclusions hold only so long as head diffraction can be ignored.) At low frequencies the image displacement produced by the delay τ_l is, like the preceding case, in the wrong direction, but the total interaural phasiness which we saw in the preceding case only occurs if $L = R$, so that these phasors go through complete nulls. With widely spaced microphones, sources near the center thus exhibit the worst phasiness, with interaural levels and phases "swishing" around in an apparently haphazard way. To minimize this phasiness and maximize the frequency range over which some imaging is achieved, one is forced to reduce τ_l. Ultimately we reach $\tau_l = 0$, coincident microphones, and good imaging, given a proper choice of polar patterns.



THE AUTHOR

Stanley P. Lipshitz was born in Cape Town, South Africa, in 1943 and received his Ph.D. in mathematics from the University of the Witwatersrand, Johannesburg, in 1970. Since then he has been at the University of Waterloo, Waterloo, Ontario, where he currently holds the rank of associate professor in both applied mathematics and physics. He has always had a keen interest in the entire field of audio and electroacoustics, and now devotes his research effort to the many problems raised by the subject.

Dr. Lipshitz is a fellow of the Audio Engineering Society, and has contributed papers at conventions and to the Journal *(many in collaboration with his colleague John Vanderkooy) on a wide range of topics including pickup arm dynamics, RIAA equalization networks, feedforward amplifier design, loudspeaker crossover networks, boundary microphone acoustics, analog tape polarity and phase standards, electroacoustic measurements, and digital audio. Being the vice-president of the Kitchener-Waterloo Chamber Music Society, and being involved in the recording and broadcasting of most of its concerts, satisfies his muscial interests, and also enables him to experiment with various recording techniques.*